BIOLOGICAL EVALUATION OF GYPSY MOTH

AT

Cuyahoga Valley National Recreation Area

1999

Prepared by

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ABSTRACT

In the fall of 1999, personnel from Cuyahoga Valley National Recreation Area (CVNRA) consisting of both permanent staff and park volunteers and the USDA Forest Service conducted gypsy moth egg mass surveys at CVNRA. The purpose of these surveys was to evaluate gypsy moth population densities and to assess the potential for defoliation and the need for treatment in 2000. Existing populations were found to be sufficient to cause heavy defoliation on an estimated 10,840 acres in 2000. In 1999, CVNRA experienced severe drought conditions throughout the growing season in addition to 4,031 acres of moderate to heavy gypsy moth defoliation. As a result, the projected level of defoliation in 2000 will likely result in oak mortality in excess of 25 percent throughout much of the park. At highest risk, are those areas previously defoliated. Treatment to prevent defoliation is recommended in those areas where this level of tree mortality conflicts with existing management objectives.

METHODS

For purposes of the survey, the park was divided into 47 survey areas that were used to delegate survey work responsibilities. Only areas containing susceptible host tree species (primarily oaks) were included in the survey. The number of sample plots within each unit was based on the number of forested acres per unit area. A minimum of four plots was used and one additional plot added for every 25 acres of forested area within each designated survey unit. A total of 575 survey plots was conducted throughout the park.

Within each area, gypsy moth survey plots were randomly selected based upon available host trees (mainly oaks), number of acres and uniformity between egg mass counts. At each sample point, a $1/40^{th}$ acre fixed radius plot was established and the percent new (1999) egg masses determined. The plots consisted of a tally of all egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by the ratio of new egg masses and then by 40 to determine the number of egg masses per acre (Liebhold et al., 1994). The survey results were then averaged for each survey area to estimate egg mass density.

Egg mass length was estimated by measuring 5 randomly selected egg masses in or near each plot to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) for each survey area was used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The 47 survey areas are presented in Figure 1 and summarized in Table 1. Overall, average egg mass densities ranged from 0-12,894 egg masses per acre. Average egg mass lengths ranged from 18-50 mm. Forty-one of the survey areas, encompassing 10,840 acres contain egg mass densities sufficient to cause moderate to heavy defoliation, based on a threshold of 750(+) egg masses per acre. Unless significant blow-in of gypsy moth caterpillars occurs in the spring, the remaining 6 survey areas are not likely to have significant defoliation in 2000.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include; previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food (mainly oaks); and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (1-30 percent); moderate (31-60 percent); and heavy (61-100 percent).

Survey results indicate the potential exists for moderate to heavy defoliation to occur on approximately 10,840 acres where egg mass densities exceed 750 egg masses/acre. Elsewhere in CVNRA, noticeable defoliation is not likely to occur (490 acres).

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity increases the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, this information can be used to correlate the predicted defoliation of an area and for simplicity, the predicted defoliation has been categorized into the previously mentioned defoliation categories (Table 1).

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be building and healthy throughout most areas surveyed at CVNRA. The average egg mass length in 32 of the 47 areas surveyed is 25mm or larger (Table 1). Egg masses larger than 25mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining populations. Both of these entomopathogens were observed in gypsy moth caterpillar cadavers collected from the park in 1999 but apparently conditions were not conducive to develop to epizootic levels. Although it is still possible that either the gypsy moth fungus or the NPV could cause the general collapse of the gypsy moth population next year, it is unlikely that populations will collapse prior to a significant defoliation event occurring in 2000.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. A more immediate and direct effect of defoliation is through the loss of oak mast. This occurs primarily from caterpillar feeding damage to flowers as well as foliage. Excessive foliage loss causes a lack of carbohydrates and results in the abortion of immature acorns. It is possible to have several years of complete acorn failure during and following years of moderate to heavy defoliation (Gottschalk, 1990).

In general, trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent

defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. Gypsy moth caused defoliation has been occurring in localized areas at CVNRA at various intensities since 1996. In 1999, defoliation became widespread and affected 4,031 acres within the park (Figure 2). In addition, severe drought conditions existed in this area during the 1999 growing season.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63 to 78 percent of the species composition, a loss of 25 percent of the total oak sawtimber and 14 percent of the total oak poletimber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality.

Because of droughty conditions and extensive defoliation that occurred in 1999, some level of tree mortality is likely to result in some areas of CVNRA. In the Happy Days/Ledges area significant tree mortality can already be observed. Should heavy defoliation occur again in 2000, the intensity of tree mortality would increase throughout portions of the park. Areas where the risk of tree mortality would be expected to be highest (> 25 % of the total host species) are those that were previously defoliated, have high egg mass densities averaging more than 750 egg masses per acre and have healthy gypsy moth populations. These conditions exist in portions of 28 areas that were surveyed, encompassing approximately 8,463 acres. A moderate level of tree mortality (10-25%) can be expected in portions of 9 areas surveyed, encompassing approximately 1,897 acres. In the remaining survey areas (approximately 980 acres), less than 10 percent tree mortality is likely to occur. Table 1 identifies these areas for your consideration.

Management Options

For 2000, three management options have been evaluated for managing gypsy moth populations at CVNRA. Resource managers at CVNRA have previously determined that chemical insecticides will not be considered and therefore only microbial intervention tactics are presented. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent tree mortality; and 2) reduce gypsy moth population below treatment thresholds. Ultimately, resource management objectives should dictate which option is desirable for managing gypsy moth populations within a given area. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse without intervention due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga.* In areas with defoliating level gypsy moth populations (greater than 750 egg masses per acre) viral epizootic episodes generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels. Although it is not possible to accurately assess such events with the information at hand, it is unlikely that a collapse will occur prior to significant defoliation in 2000, since most areas are newly infested and there is an abundance of large-healthy egg masses.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al. (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that defoliation will occur and gypsy moth populations will increase in new infestations and expand to non-infested areas at CVNRA.

Microbial Insecticide Options

B.t.k.: The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (B.t.k).* This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *B.t.k.* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis and occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *B.t.k.* is persistent on foliage for about 7-10 days.

B.t.k. has been shown to impact other non-target caterpillars that are exposed to the treatment and are actively feeding. An example of the potential impacts is provided by a studies conducted by Miller (1990) in Oregon and Samples, et al. (1996) in West Virginia. Miller's study involved a large-scale eradication program where three consecutive applications of *B.t.k.* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *B.t.k.* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1-year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

B.t.k. formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *B.t.k.* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *B.t.k.* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymantriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is $2x10^{11}$ occlusion bodies (OB's) per acre applied in two applications, 3-5 days apart. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments.

RECOMMENDATIONS

Egg mass size and densities indicate that gypsy moth populations throughout most of the park are healthy and building. An integrated approach to managing gypsy moth populations is recommended and takes into account park management objectives, pest population densities, projected damage and the consequences of doing nothing. Treatment should be conducted in those areas where egg mass densities are sufficient to cause defoliation (750 egg masses per acre) and where it has been determined that park management objectives will be affected by either the defoliation or subsequent tree mortality. No intervention action is recommended in areas where gypsy moth populations average below 750 egg masses per acre or the predicted defoliation and tree mortality can be tolerated when park management objectives are considered.

Within areas designated for treatment, two applications of *B.t.k.* at 36 billion international units (BIU's) applied in a total mix of ¾ gallon per acre is recommended. The two applications should be spaced by 5-7 days.

To accommodate the lepidopteran monitoring activities within the park, approximately 800 acre equivalent of Gypchek will be made available to CVNRA and is recommended providing these areas meet treatment thresholds.

These recommendations are based on the following considerations:

1. A double application of *B.t.k.* on areas where gypsy moth populations are building and have high densities would provide foliage protection and population reduction.

2. Treating areas designated for monitoring moth and butterfly populations with Gypchek will provide sufficient foliage protection and not impact non-target species.

REFERENCES

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TABLE 1. GYPSY MOTH SURVEY RESULTS
CUYAHOGA VALLEY NRA, 1999

Survey Area #	Name	Acres	EM/Acre	Ave EM Length (mm)	# of Plots	Est. Defoliation Levels in 2000 [1]	Block Defol. In 1999?	Potential Tree Mortality [2]
2	LTV	59	4351	31	5	H	N	M
3	Canal VC	218	1570	25	12	M	N	M
4	Terra Vista	183	1068	34	10	M	Y	M
6	Bedford Reservation	101	211	27	7	L	N	L
7	Gravesite	23	1080	32	4	M	N	M
8	Chaffee	294	5513	24	15	H	Y	H
9	CMA	196	1186	30	11	M	Y	H
10	Carriage Trail	754	8084	21	33	H	Y	H
11	Snowville/ Columbia	635	4910	24	27	H	Y	H
12	Columbia S	87	1743	19	6	M	N	M
13	Buckeye Trail	108	4703	26	6	H	Y	H
14	Blue Hen Falls	187	2560	28	10	H	Y	H
15	Between the Highways	73	2520	30	6	H	Y	H
16	Black Road	23	1234	41	4	M	Y	H
17	Horseshoe Pond	335	1188	30	16	M	Y	H
18	Oak Hill	690	7739	25	25	H	Y	H
19	Furnace Run	529	8066	25	24	H	Y	H
20	Riding Run	288	1952	31	14	H	Y	H
22	Perkins Run	154	431	29	9	L	Y	L
23	Indigo Lake	140	2185	50	8	H	N	M
24	Oneil Woods	256	1408	20	13	M	N	M
25	Indian Mound	45	0	--	5	N	N	L
26	Dorms	119	129	41	7	L	N	L
27	Brandywine	471	3998	28	22	H	Y	H
28	Stanford	154	4130	23	8	H	Y	H
29	Krecji N	256	11,331	30	13	H	Y	H
30	Krecji S	352	9707	23	17	H	Y	H
31	A-P/Boston Mills	520	8527	24	24	H	Y	H
32	Pine Lane S	117	10,641	32	8	H	Y	H
33	Boston Run	246	925	20	13	M	Y	L
34	Happy Days/Ledges	653	1156	23	29	M	Y	M
35	VK Lake	646	4004	23	29	H	Y	H
36	Quick S	123	1329	35	8	M	Y	H
37	Wetmore N	210	2614	18	11	M	Y	H
38	Wetmore S	228	10,513	29	12	H	Y	H
39	Armington	177	5900	30	10	H	Y	H
40	Blossom	55	851	38	5	M	N	M
41	Steeles Corner	16	10	37	4	L	N	L

TABLE 1. GYPSY MOTH SURVEY RESULTS
CUYAHOGA VALLEY NRA, 1999 (cont.)

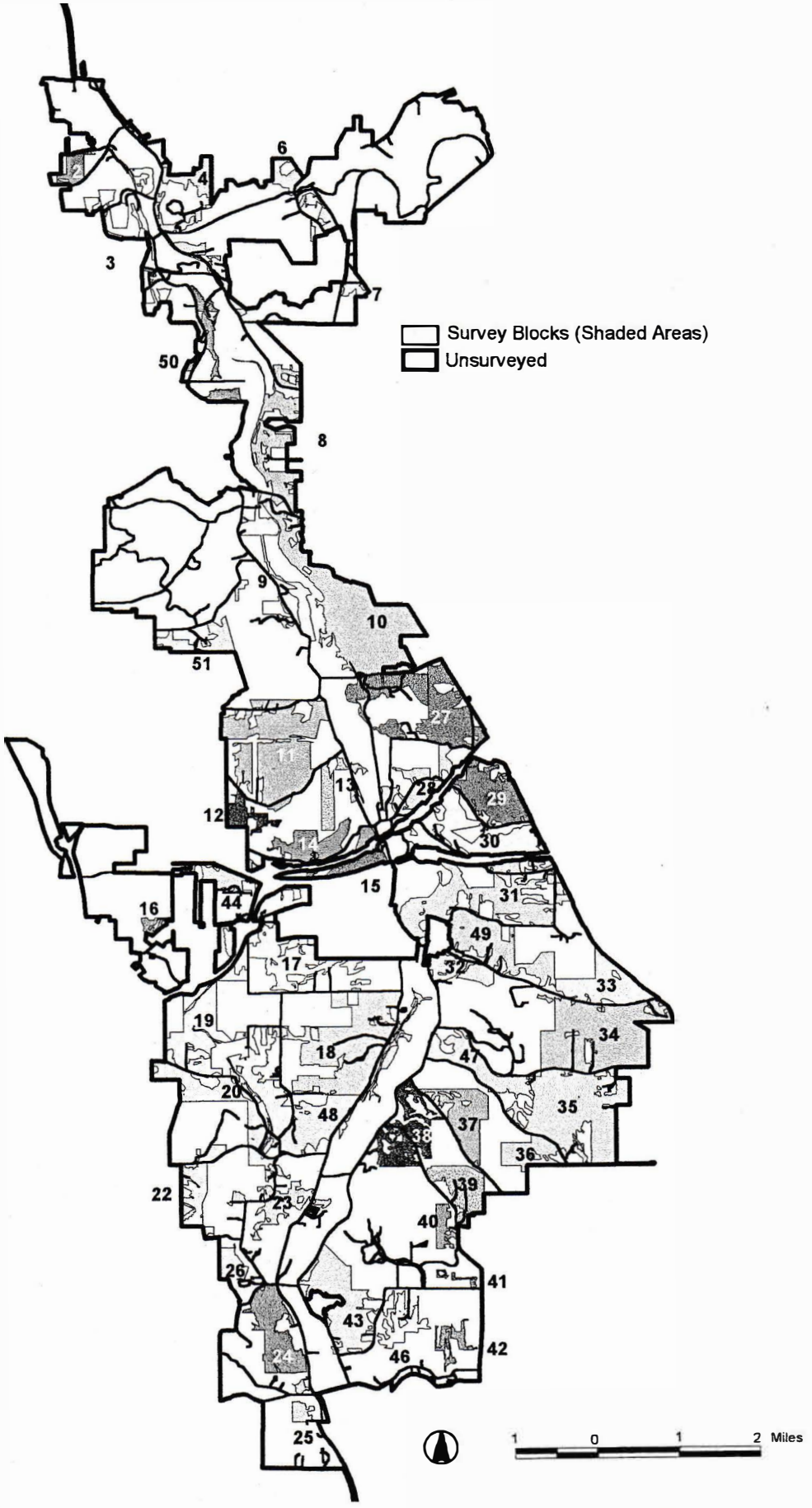
Survey Area #	Name	Acres	EM/Acre	Ave EM Length (mm)	# of Plots	Est. Defol. Levels in 2000 [1]	Block Defol. 99	Potential Mortallity [2]
42	Bath/ Northampton	55	60	50	2	L	N	L
43	Towpath Village	350	2680	33	16	H	N	M
44	Coliseum	95	4317	28	7	H	N	M
46	Parry	117	955	34	8	M	N	M
47	Salt Run	212	12,894	23	11	H	Y	H
48	EEC	260	8729	29	13	H	Y	H
49	Pine Lane N	296	2894	27	15	M	Y	H
50	Rail Yard	110	1378	32	5	M	Y	H
51	Brecksville	114	1501	21	8	M	Y	H

1] Egg mass density x length (mm) = eggs/acre to predict defoliation intensity.
None; Light (1-30%); Moderate (31-60%); and Heavy (61-100%). (Modified from Liebhold et al., 1993)
N = 45 acres
L = 445 acres
M = 3245 acres
H = 7595 acres

2] Potential mortality is a "best guess" estimate based on: 1) prior defoliation; 2) risk of defoliation in 2000; 3) the assumption that trees are under stress from the 1999 drought; and 4) mortality events that have occurred elsewhere under similar circumstances. The utility of these estimates are to identify which areas have the greatest risk to tree mortality as actual mortality levels may vary considerably and be scattered within individual survey areas.

Low: < 10% mortality (736 acres)
Moderate: 10-25% mortality (2,236 acres)
Heavy: > 25% mortality (8,358 acres)

Figure 1. Gypsy Moth Egg Mass Survey Blocks, Cuyahoga Valley National Recreation Area, Ohio
November 1999



1999

USDA United States Department of Agriculture | Forest Service | Northeastern Area State and Private Forestry | 180 Canfield Street Morgantown, WV 26505- 3101

File Code: 3460
Date: January 25, 2000

John Debo, Superintendent
Cuyahoga Valley National Recreation Area
15610 Vaughn Road
Brecksville, OH 44141

Dear John:

Enclosed is a gypsy moth biological evaluation for Cuyahoga Valley National Recreation Area conducted in 1999. Included is our recommendation of treatment of those areas that you determine the predicted defoliation in 2000 and/or tree mortality would conflict with your management objectives.

In brief, gypsy moth populations are extremely high throughout much of the Park and widespread defoliation is likely to occur in 2000 unless some intervention action is taken. The gypsy moth fungus *Entomophaga maimaiga* is known to exist in your area but it is not likely to have an impact on gypsy moth populations before significant defoliation occurs.

I believe this evaluation will provide you the information to make the necessary management decisions but if you would like further information, please feel free to contact Brad Onken of my staff at (304) 285-1546. Brad has been working with your resource management staff and speaks highly of the work of Kevin Skerl. Kevin's effort in this project has been exemplary.

Because of the number of private lands in and around the Park boundary involved in the State Gypsy Moth Suppression Program, coordination of state and federal treatment plans are critical. Brad will continue to coordinate the planning phase of this cooperative project and will be available to the Park to provide any technical assistance needed during aerial treatment operations.

Sincerely,

for JOHN W. HAZEL
Field Representative
Morgantown Field Office

Enclosure

cc: Kevin Skerl, NPS-CVNRA
Garree Williamson, NPS-CVNRA
Steve Cinnamon, NPS-Midwest Region, IPM Coordinator
Noel Schneeberger, AO
Allison Marcum, ODA